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Reduce Fluid Experiment System Flight Data from IML-1

by

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TABLE OF CONTENTS

INTRODUCTION

The Microgravity Science and Applications program at NASA has been instrumental in providing innovative research for the crystal growth community. Since a microgravity (10^{-4} - 10^{-6} g) experiment is influenced by neither convection nor buoyancy, new information can be obtained from studying the growth of large single crystals in space. With the earth's gravitational force eliminated, forces otherwise negligible now become predominant and can therefore be more thoroughly investigated. In addition, crystal lattice defects can be theoretically minimized with the absence of gravity. As a result, researchers hope to produce crystals in space superior to those grown on earth.

The Fluid Experiment System (FES) is a Marshall Space Flight Center (MSFC) flight experiment facility, dedicated to the analysis of crystal growth experiments aboard the shuttle. The FES materials are grown from seed crystals placed in cell chambers filled with liquid growth solution. The cells are installed in a Spacelab double rack and controlled with standard facilities such as power, avionics, air and water, and the results from the forming crystal are recorded with holograms taken at chosen time intervals.

The Holographic Ground System (HGS) at MSFC is the FES ground support facility for applying optical techniques to the flight holograms to study solidification processes and surrounding fluid dynamics of the space grown crystals. It consists of a large air-suspended optical table located in a lightproof room. The table is outfitted with optical components that provide holographic construction and reconstruction, interferometry, schlieren, and microscopy. The HGS also includes a large quantity of computer equipment for processing resultant holographic images.

HGS

The Holographic Ground System (HGS) facility recently installed new equipment necessary for updating image transferral and storage procedures as well as improving the image acquisition capabilities.

- A fiber-optic ethernet running at 3500 baud and linked to the MSFC central computer network.

- A 2-Gigabyte optical storage drive, allowing for permanent storage of approximately 8000 images per disk.

- A high resolution (5u per step) x-y-z translation mount for image scanning in three dimensions. This mount possesses accuracies of 1u per inch of travel, 5 arcseconds of orthogonality, and maximum deviation (straightness or flatness) of 2u per 10 cm or travel.

- A high-sensitivity camera with microscope objective lens adaptor. This camera is lightweight to minimally stress the translation motors.

- The Imaging Technology, Inc. Series 151 image processing system with a library of image processing functions.

TGS EXPERIMENT

BENEFITS OF THE TGS CRYSTAL

The triglycine sulfate (TGS) crystal was chosen as a microgravity research material for a number of reasons. It has a high theoretical efficiency for light detection, detects a wide range of light wavelengths (visible to infrared), and is capable of detecting in ambient conditions. Commercial applications for TGS include medical imaging, earth resource surveying, fire detection, and astronomical telescope design. Current use of TGS has been limited, however, due to its slow growth rate which makes it highly susceptible to gravitational influences. In microgravity, researchers hope to minimize these imperfections by placing the seed in the near convection-free environment of space.

OBJECTIVES

The TGS experiment attempts to isolate and quantify fluid convection components, specifically from crystal growth, g-jitter, residual microgravity, and other acceleration forces. Identifying these components and correlating them with other events enables more accurate characterizations of the space shuttle environment and its effects on crystal growth. Therefore small particles or microspheres were seeded into the TGS fluid to depict these fluid forces.

SPECIFICATIONS

While performing the tests to determine the particle concentration in the TGS solution, it was noted that extremely small particles were invisible during the real-time recording. By contrast, large particles were usually damaged by the stir motor, which produced unwanted nucleation sites. Therefore, it became necessary to establish a median particle diameter range of approximately 200 u to 650 u, with enough spacing between diameters to distinguish each particle. The three diameters used were 199u, 383u, and 646u.

Due to the cohesive and adhesive properties of the particles, excess quantities were needed in the solution to accommodate for clumping and for sticking to the container walls. Although the large numbers of particles provided measurable data, they also caused tracking difficulties, especially during shuttle maneuvers or other large disturbances. A full scan to obtain statistics on sphere loss will be conducted in the future.

The particle spheres were measured in mass, from which the particle concentration per unit volume of solution could be calculated.

Particle Diameter	Measured Mass	# particles per gram
199 u	0.0391 g	2.3×10^5 /g
383 u	0.2812 g	3.2×10^4 /g
646 u	1.4060 g	6.4×10^3 /g

The total number of spheres of each size is given by the following calculations.

199 u:	(2.3 x 10 /g)(0.0391 g)	=	8993 spheres
383 u:	(3.2 x 10 /g)(0.2812 g)	=	8998 spheres
646 u:	(6.4 x 10 /g)(1.4060 g)	=	8992 spheres
	TOTAL	=	26983 spheres

The cell's volume = 1.8 liters including the heat exchanger. Therefore, the average particle concentration was

$$\frac{26983 \text{ spheres}}{1800 \text{ cc}} = 15 \text{ spheres / cc}$$

$$= 5 \text{ spheres/cc of each size.}$$

EXPERIMENTAL APPROACH

BACKGROUND

Originally, two crystal growth experiments were planned, lasting approximately 24 hours and 60 hours. Due to problems encountered during flight, these two experiments were reduced to three shortened runs. The first, Run 1A, was 8.5 hours, Run 1B was 28.5 hours, and Run 1C was 19 hours. Run 1A was a cold cell with the cap never retracting. In Run 1B, the cell was heated, but the cap was never retracted. With Run 1C, the cell was heated and the cap raised successfully.

Data collected from these runs included approximately 1050 images reconstructed from the 114 holograms recorded during Run 1A. Run 1C contributed 136 holograms from which approximately 2350 images of moving microparticles were obtained. There were 133 holograms recorded during Run 1B, and more microparticle data will be collected from them in the future (refer to Appendix A for the complete Hologram Database).

The TGS experiments use the Computerized Holographic Image Processing (CHIP) program to record these images into computer files for velocity/acceleration data. The CHIP program was originally established for automated schlieren analysis, but it can be efficient for surveying holograms in a three-planar image matrix. Each image is saved with a filename indicative of its position in the matrix (see Figs. 1 and 2 of Appendix B). The following discussion explains how these images are acquired.

SCANNING PROCEDURE DISCUSSION

The image acquisition procedure uses the following equipment: the CHIP image processing program, the Series 151 Image Processing System with Itex 151 library of image processing functions, a high-sensitivity camera fitted with microscope objective lenses, two TV monitors and PC's, a UNIDEX stepper motor driver to control a three-axis mount for camera positioning. This UNIDEX motor controller can be controlled by the CHIP program or manually with a joystick for rough positioning.

CONDITIONS AND CALCULATIONS

Previous to the image acquisition, the camera was positioned correctly using the procedure located in Appendix C. Before obtaining any images with the computer, we first established the height and width of an image in reference to the UNIDEX motor. Since one "step" of the motor moves the camera 5 microns, we made the following measurements and calculations:

Image width (shown on monitor) = 2030 steps
Image width (actual) = 10.15 mm
Image height (shown on monitor) = 1562 steps
Image height (actual) = 7.81 mm

A 10% horizontal overlap and a 10% vertical overlap was employed between neighboring images to aid in later image comparisons. This required recalculating the above values to find the number of steps needed to move the camera to the next image.

Horizontal distance between each image
= 2030 steps x 90%
= 1827 steps (9.09 mm)
Vertical distance between each image
= 1562 steps x 90%
= 1405 steps (7.03 mm)

Therefore, to obtain neighboring images, the motor must move the camera 1827 steps horizontally or 1405 steps vertically. Since the distance between image depths was desired to be about 1 cm, this third dimension was chosen to also be 1827 steps or 9.09 mm for uniformity.

SET-UP PROCEDURE (INITIALIZATION)

The following steps are required for initialization of the Computerized Holographic Image Processing Program:

1. Make a directory of each hologram. Keeping a directory is important so that the image files (which have like labeling) are not overwritten. The directory name is the same as the sleeve number of the hologram (ex. 2T1CP100). Each image is stored into one file in this directory, the filename referring to its location in the matrix. The filename is in the form *vertical position.angle,* where the *vertical position* is the matrix y-value, and the *angle* denotes the matrix x-value and focus positions. Referring to Fig. 2 of Appendix B, for example, the file 1405.2B stores the image located in the matrix block with the vertical (y) position "1405," horizontal (x) position "2," and plane (focus) position "B." The filename for the very first image is 0.1A. All directories are located on Bernoulli disks which contain 90 MB of memory.

2. Find the reference point. This step requires focusing on the middle plane, then finding the appropriate starting point on the plane.

- Use the joystick manually to position the sting at approximately the monitor's center in order to offer a "good" sting view;
- To focus, flip the x-axis dial to FOCUS and move the joystick in the positive or negative x-direction. The camera is now set at the "B," or middle plane.
- Flip the x-axis dial back to HORIZONTAL and position the camera to center the matrix over the sting (500 steps were chosen).

3. Initialize the CHIP program for use. This step connects the CHIP program to the UNIDEX and prepares the files for storing the images.

- On the UNIDEX, press RESET so that the display reads SYS RDY;
- While in the hologram's directory, type CHIP to enter the CHIP program;
- Once in the CHIP program, press the UDX ONLINE and AUTO UDX keys to connect the program to the UNIDEX;

- Press HOLO CODE and enter the last six digits of the hologram name (from the earlier example, the last six digits would be 1CP100);
- Press ANGLE and enter the appropriate angle and plane (1A, 2B, etc.);
- Move the camera to the desired plane: on the UNIDEX, flip the x-axis dial to FOCUS. Press INCX, enter 1827, then press GO to execute. The image on the screen should change in focus but not in position.

Appendix B gives the step-by-step procedures to record all necessary images on the hologram matrix. There are separate procedures for TGS runs 1A and 1C due to the cell center's being obstructed (Run 1A) or unobstructed (Run 1C), but all initializations discussed up to this point are the same. Each procedure is written to capture a single plane or depth of the matrix, and at its conclusion the film must be replaced with the next hologram. After all necessary images are surveyed in one plane, the procedure may be repeated for the remaining planes. This approach is used to minimize position errors induced by the switching of step motors with the UNIDEX controller.

IMAGE ARCHIVAL

Once the images are scanned, they are then saved in a format unique to CHIP. A conversion needs to be carried out to transform these images to a more compatible format for other users. Imaging Technology, Inc. was chosen as a standard format. To transform the image files, they should be converted to the following format:

Bytes	Contents
0-63	Header area, consisting of the following parameters:
0-1	The letters IM (Hexadecimal values 49 and 4D)
2-3	Size of comment area
4-5	Width of the image, in pixels
6-7	Height of the image, in lines
8-9	Coordinates of original x-axis (horizontal) position
10-11	Coordinates of original y-axis (vertical) position
12-13	File type flag; values may be: 0=normal; 1=compressed; 2=special
14-63	Reserved
64-nnn	Comment area (variable in length; 255 bytes maximum. See bytes 2-3 for actual length)
nnn/1-mmm	Data area (1 byte per pixel stored in row order, from the top to the bottom of the image)

Once converted, the images occupy 0.25 Megabytes of memory. Locally, they are stored on 90 Megabyte Bernoulli disks; however, the optical disk drive is required for long-term storage. This drive is accessed through the fiberoptic network that is linked to the Marshall Space Flight Center central computer network, allowing for world-wide image communication. The images are transferred to the optical drive by way of a VAX controller (the complete procedure is located in Appendix D).

The optical drive is known as a WORM (Write Once Read Many) drive. It requires the disk to be preformatted with an organized structure and given numbers of files and sizes. The structure of the first disk is listed in Appendix A. The optical disk contains one Gigabyte of memory per side of the platter, which translates to approximately 8000 images per disk.

PHOTOGRAPHIC DISPLAYS

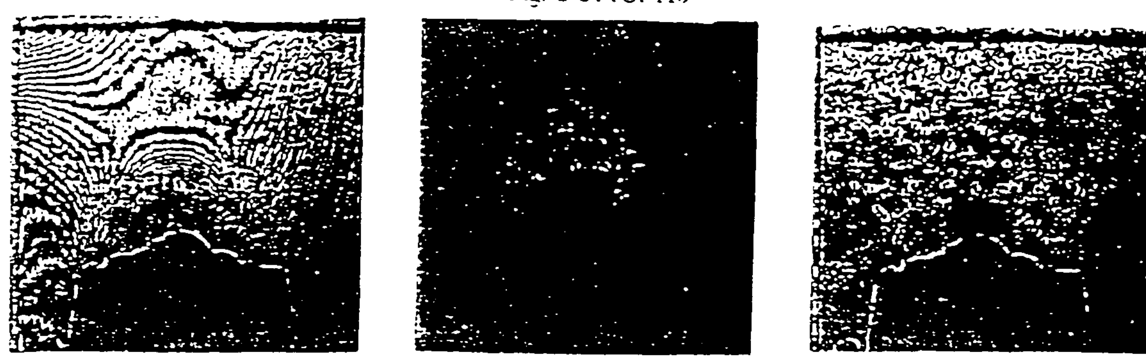
In addition to the particle velocimetry data discussed thus far, there will be further research into the changing fluid concentration environment around the growing crystal. To lay the groundwork for this work, three different photographs were taken of cell interior images from successive holograms. These photographs were of interferogram, schlieren, and shadowgraph images. Diagrams of the optical bench layouts to acquire these photographs are detailed in Appendix E.

Figures 1, 2, and 3 show sample photographs of some 2T1CP images (holograms 044, 110, 176, and 224). The interferograms will be used to show absolute fluid densities at given times in the run. The change in these densities or their gradients will be evaluated with the schlieren photograph data. The shadowgraph photographs will be used to show the changes that occur in the density gradients over time. It also gives a full, unobstructed view of the cell and crystal.

Fig. 1 2T1CP044

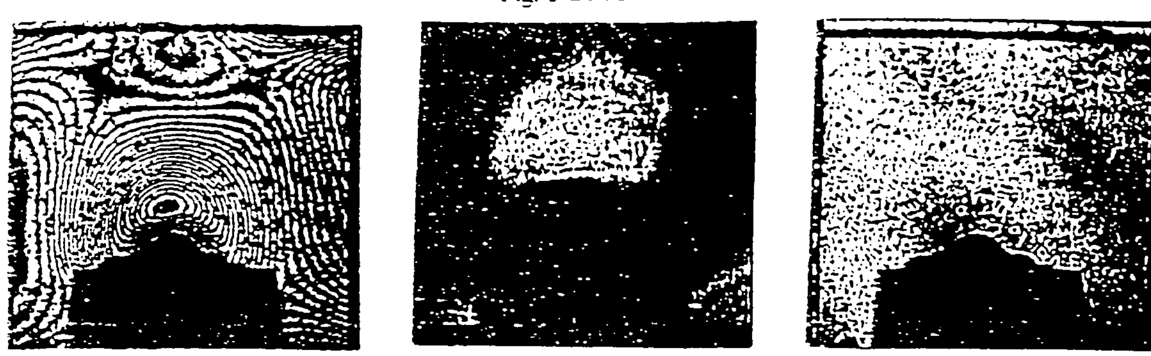
(a) Interferogram (b) Schlieren (c) Shadowgraph

Fig. 2 2T1CP110



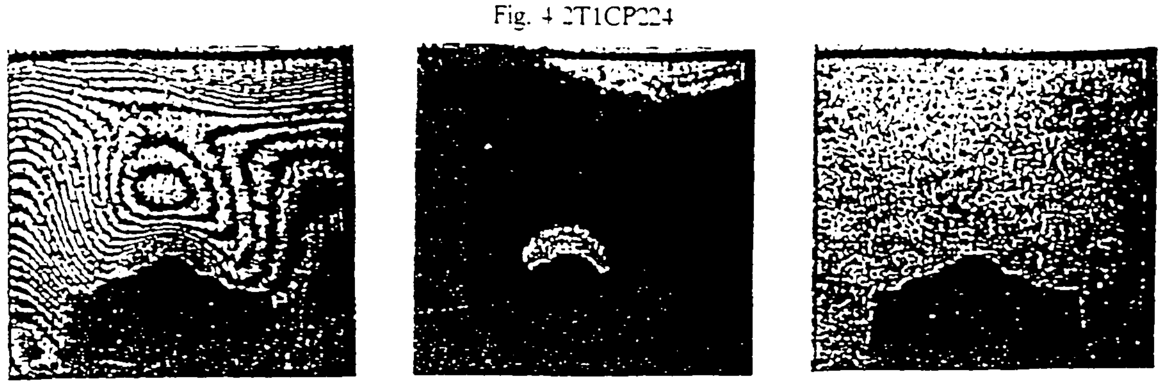
(a) Interferogram (b) Schlieren (c) Shadowgraph

Fig. 3 2T1CP176



(a) Interferogram (b) Schlieren (c) Shadowgraph

Fig. 4 2T1CP224



(a) Interferogram (b) Schlieren (c) Shadowgraph

APPENDIX A:
HOLOGRAM AND OPTICAL DRIVE DATABASES

Holo Number	Hologram Code		Hologram Type	Quality	GMT	MET	TGS Mode
44	2T1AP044	****	S	Drk	25:5:7:22	2:14:14:48	3
45	2T1AP045		SD		25:5:8:7	2:14:15:33	3
46	2T1AP046		S		25:5:15:49	2:14:23:15	3
47	2T1AP047		S		25:5:26:57	2:14:34:23	3
48	2T1AP048		SD		25:5:27:45	2:14:35:11	3
49	2T1AP049		S		25:5:35:25	2:14:42:51	3
50	2T1AP050		SD		25:5:36:13	2:14:43:39	3
51	2T1AP051		S		25:5:43:55	2:14:51:21	3
52	2T1AP052		SD		25:5:44:43	2:14:52:9	3
53	2T1AP053		S		25:5:52:25	2:14:59:52	3
54	2T1AP054		SD		25:5:53:13	2:15:0:39	3
55	2T1AP055		S		25:6:0:55	2:15:8:21	3
56	2T1AP056		SD		25:6:1:43	2:15:9:9	3
57	2T1AP057		S		25:6:9:25	2:15:16:51	3
58	2T1AP058		SD		25:6:10:13	2:15:17:39	3
59	2T1AP059		S		25:6:17:55	2:15:25:21	3
60	2T1AP060		SD		25:6:18:43	2:15:26:9	3
61	2T1AP061		S		25:6:26:25	2:15:33:51	3
62	2T1AP062		SD		25:6:27:13	2:15:34:39	3
63	2T1AP063		S		25:6:34:55	2:15:42:21	3
64	2T1AP064		SD		25:6:35:42	2:15:43:8	3
65	2T1AP065		S		25:6:43:24	2:15:50:50	3
66	2T1AP066		SD		25:6:44:12	2:15:51:38	3
67	2T1AP067	****	S		25:6:51:54	2:15:59:20	3
68	2T1AP068	****	SD		25:6:52:42	2:16:0:8	3
69	2T1AP069	****	S		25:7:0:24	2:16:7:50	3
70	2T1AP070	****	SD		25:7:1:12	2:16:8:32	3
71	2T1AP071		S		25:7:8:53	2:16:16:19	3
72	2T1AP072		SD		25:7:9:40	2:16:17:6	3
73	2T1AP073		S		25:7:17:22	2:16:24:48	3
74	2T1AP074		SD		25:7:18:10	2:16:25:36	3
75	2T1AP075		S		25:7:25:51	2:16:33:17	3
76	2T1AP076		SD		25:7:26:39	2:16:34:5	3
77	2T1AP077		S		25:7:34:21	2:16:41:47	3
78	2T1AP078		SD		25:7:35:9	2:16:42:35	3
79	2T1AP079		S		25:7:42:51	2:16:50:17	3
80	2T1AP080		SD		25:7:43:39	2:16:51:5	3
81	2T1AP081		S		25:7:51:21	2:16:58:47	3
82	2T1AP082		SD		25:7:52:9	2:16:59:35	3
83	2T1AP083	****	S		25:7:59:51	2:17:7:17	3
84	2T1AP084	****	SD		25:8:0:39	2:17:8:5	3
85	2T1AP085	****	S		25:8:8:21	2:17:15:47	3
86	2T1AP086	****	SD		25:8:9:9	2:17:16:36	3
87	2T1AP087	****	S		25:8:16:51	2:17:24:17	3
88	2T1AP088	****	SD		25:8:17:39	2:17:25:6	3
89	2T1AP089		S		25:8:25:19	2:17:32:45	3

**** - DATA LOSS; GMT and MET may not be exact

Holo Number	Hologram Code		Hologram Type	Quality	GMT	MET	TGS Mode
90	2T1AP090		SD		25:8:26:7	2:17:33:33	3
91	2T1AP091	****	S		25:8:33:49	2:17:41:15	3
92	2T1AP092	****	SD		25:8:34:37	2:17:42:3	3
93	2T1AP093	****	S		25:8:42:19	2:17:49:45	3
94	2T1AP094	****	SD		25:8:43:7	2:17:50:33	3
95	2T1AP095		S		25:8:50:48	2:17:58:14	3
96	2T1AP096		SD		25:8:51:35	2:17:59:1	3
97	2T1AP097		S		25:8:59:17	2:18:6:43	3
98	2T1AP098		SD		25:9:0:5	2:18:7:31	3
99	2T1AP099		S		25:9:7:48	2:18:15:14	3
100	2T1AP100		SD		25:9:8:36	2:18:16:2	3
101	2T1AP101		S		25:9:16:18	2:18:23:44	3
102	2T1AP012		SD		25:9:17:6	2:18:24:32	3
103	2T1AP103	****	S		25:9:24:48	2:18:32:14	3
104	2T1AP104	****	SD		25:9:25:36	2:18:33:2	3
105	2T1AP105	****	S		25:9:33:18	2:18:40:44	3
106	2T1AP106	****	SD		25:9:34:6	2:18:41:32	3
107	2T1AP107		S		25:9:41:45	2:18:49:11	3
108	2T1AP108		SD		25:9:42:33	2:18:49:59	3
109	2T1AP109		S		25:9:50:16	2:18:57:42	3
110	2T1AP110		SD		25:9:51:4	2:18:58:30	3
111	2T1AP111		S		25:9:58:46	2:19:6:12	3
112	2T1AP112		SD		25:9:59:33	2:19:6:59	3
113	2T1AP113	****	S		25:10:7:16	2:19:14:42	3
114	2T1AP114	****	SD		25:10:8:4	2:19:15:30	3
115	2T1AP115	****	S		25:10:15:46	2:19:23:12	3
116	2T1AP116	****	SD		25:10:16:34	2:19:24:0	3
117	2T1AP117	****	S		25:10:24:16	2:19:31:42	3
118	2T1AP118	****	SD		25:10:25:4	2:19:32:30	3
119	2T1AP119	****	S		25:10:32:46	2:19:40:12	3
120	2T1AP120		SD		25:10:33:34	2:19:41:0	3
121	2T1AP121		S	Loan	25:10:41:15	2:19:48:41	3
122	2T1AP122		SD		25:10:42:3	2:19:49:29	3
123	2T1AP123		S		25:10:49:45	2:19:57:11	3
124	2T1AP124		SD		25:10:50:33	2:19:57:59	3
125	2T1AP125		S	Loan	25:10:58:15	2:20:5:41	3
126	2T1AP126		SD		25:10:59:3	2:20:6:29	3
127	2T1AP127		S		25:11:6:45	2:20:14:11	3
128	2T1AP128	****	SD		25:11:7:33	2:20:14:59	3
416	2T2P160		S (man)	Blk	26:20:9:39	4:5:17:5	3
417	2T2P161		S (man)	Blk	26:20:12:20	4:5:19:46	3
418	2T2P162		S (man)	Blk	26:20:18:48	4:5:26:14	3

**** - DATA LOSS; GMT and MET may not be exact

Holo Number	Hologram Code		Hologram Type	Quality	GMT	MET	TGS Mode
419	2T1BP163	****	S (man)	Blk	27:15:41:50	5:0:49:16	
420	2T1BP164		S (man)	Blk	27:15:44:11	5:0:51:37	3
421	2T1BP165		S (man)	Blk	28:3:50:9	5:12:57:35	6
422	2T1BP166		S	Drk	28:4:52:36	5:14:0:2	6
423	2T1BP167		SD		28:4:53:24	5:14:0:50	6
424	2T1BP168		S		28:5:5:7	5:14:12:33	6
425	2T1BP169		SD	Cut5%	28:5:5:55	5:14:13:21	6
426	2T1BP170		S	Cut5%Drk	28:5:17:37	5:14:25:4	6
427	2T1BP171		SD	Cut10%	28:5:18:25	5:14:25:52	6
428	2T1BP172		S		28:5:30:7	5:14:37:33	6
429	2T1BP173		SD		28:5:30:55	5:14:38:21	6
430	2T1BP174		S		28:5:42:37	5:14:50:4	6
431	2T1BP175		SD		28:5:43:25	5:14:50:51	6
432	2T1BP176		S		28:5:55:7	5:15:2:33	6
433	2T1BP177		SD		28:5:55:54	5:15:3:20	6
434	2T1BP178		S		28:6:7:36	5:15:15:2	6
435	2T1BP179		SD		28:6:8:24	5:15:15:50	6
436	2T1BP180		S		28:6:20:6	5:15:27:32	6
437	2T1BP181		SD		28:6:20:54	5:15:28:20	6
438	2T1BP182		S		28:6:32:35	5:15:40:1	6
439	2T1BP183		SD		28:6:33:23	5:15:40:49	6
440	2T1BP184		S		28:6:45:5	5:15:52:31	6
441	2T1BP185		SD		28:6:45:53	5:15:53:19	6
442	2T1BP186		S		28:6:57:35	5:16:5:1	6
443	2T1BP187		SD		28:6:58:23	5:16:5:49	6
444	2T1BP188		S		28:7:10:5	5:16:17:31	6
445	2T1BP189		SD		28:7:10:53	5:16:18:19	6
446	2T1BP190		S		28:7:22:35	5:16:30:1	6
447	2T1BP191		SD		28:7:23:23	5:16:30:49	6
448	2T1BP192		S		28:7:35:5	5:16:42:31	6
449	2T1BP193		SD		28:7:35:53	5:16:43:19	6
450	2T1BP194		S		28:7:47:36	5:16:55:2	6
451	2T1BP195		SD		28:7:48:24	5:16:55:50	6
452	2T1BP196		S		28:8:0:7	5:17:7:33	6
453	2T1BP197		SD		28:8:0:55	5:17:8:21	6
454	2T1BP198		S	Cut10%	28:8:12:37	5:17:20:3	6
455	2T1BP199		SD		28:8:13:25	5:17:20:51	6
456	2T1BP200		S	Cut20%	28:8:25:7	5:17:32:33	6
457	2T1BP201		SD	Cut30%	28:8:25:55	5:17:33:21	6
458	2T1BP202		S	Cut25%	28:8:37:36	5:17:45:2	6
459	2T1BP203		SD		28:8:38:24	5:17:45:50	6
460	2T1BP204		S		28:8:50:6	5:17:57:32	6
461	2T1BP205		SD		28:8:50:53	5:17:58:19	6
462	2T1BP206		S		28:9:2:35	5:18:10:1	6

**** - DATA LOSS; GMT and MET may not be exact

Holo Number	Hologram Code		Hologram Type	Quality	GMT	MET	TGS Mode
463	2T1BP207		SD		28:9:3:23	5:18:10:49	6
464	2T1BP208		S		28:9:15:5	5:18:22:31	6
465	2T1BP209		SD		28:9:15:53	5:18:23:19	6
466	2T1BP210		S		28:9:27:35	5:18:35:1	6
467	2T1BP211		SD		28:9:28:23	5:18:35:49	6
468	2T1BP212		S		28:9:40:5	5:18:47:31	6
469	2T1BP213		SD		28:9:40:53	5:18:48:19	6
470	2T1BP214		S		28:9:52:35	5:19:0:1	6
471	2T1BP215		SD		28:9:53:23	5:19:0:49	6
472	2T1BP216		S		28:10:5:5	5:19:12:31	6
473	2T1BP217		SD		28:10:5:53	5:19:13:19	6
474	2T1BP218		S		28:10:17:35	5:19:25:1	6
475	2T1BP219		SD		28:10:18:23	5:19:25:49	6
476	2T1BP220		S		28:10:30:5	5:19:37:31	6
477	2T1BP221		SD		28:10:30:53	5:19:38:19	6
478	2T1BP222		S		28:10:42:35	5:19:50:1	6
479	2T1BP223		SD		28:10:43:23	5:19:50:49	6
480	2T1BP224		S		28:10:55:6	5:20:2:32	6
481	2T1BP225		SD		28:10:55:54	5:20:3:20	6
482	2T1BP226		S		28:11:7:37	5:20:15:4	6
483	2T1BP227		SD		28:11:8:25	5:20:15:51	6
484	2T1BP228		S		28:11:20:6	5:20:27:32	6
485	2T1BP229		SD		28:11:20:54	5:20:28:20	6
486	2T1BP230		S		28:11:32:37	5:20:40:4	6
487	2T1BP231		SD		28:11:33:25	5:20:40:51	6
488	2T1BP232		S		28:11:45:7	5:20:52:33	6
489	2T1BP233		SD		28:11:45:55	5:20:53:21	6
490	2T1BP234		S		28:11:57:38	5:21:5:4	6
491	2T1BP235		SD		28:11:58:26	5:21:5:52	6
492	2T1BP236		S		28:12:10:8	5:21:17:34	6
493	2T1BP237		SD		28:12:10:56	5:21:18:22	6
494	2T1BP238	****	S		28:12:22:38	5:21:30:4	6
495	2T1BP239	****	SD		28:12:23:26	5:21:30:52	6
496	2T1BP240		S		28:12:35:7	5:21:42:33	6
497	2T1BP241		SD		28:12:35:55	5:21:43:21	6
498	2T1BP242		S		28:12:47:37	5:21:55:3	6
499	2T1BP243		SD		28:12:48:25	5:21:55:51	6
500	2T1BP244		S		28:13:0:7	5:22:7:33	6
501	2T1BP245		SD		28:13:0:55	5:22:8:21	6
502	2T1BP246		S		28:13:12:37	5:22:20:3	6
503	2T1BP247		SD		28:13:13:25	5:22:20:51	6
504	2T1BP248		S		28:13:25:7	5:22:32:33	6
505	2T1BP249		SD		28:13:25:55	5:22:33:21	6
506	2T1BP250		S		28:13:37:37	5:22:45:3	6
507	2T1BP251		SD		28:13:38:25	5:22:45:51	6
508	2T1BP252		S	Blk	28:13:50:7	5:22:57:33	6

**** - DATA LOSS; GMT and MET may not be exact

Holo Number	Hologram Code		Hologram Type	Quality	GMT	MET	TGS Mode
509	2T1BP253		SD	Blk	28:13:50:55	5:22:58:21	6
510	2T1BP254		S	Blk	28:14:2:36	5:23:10:2	6
511	2T1BP255		SD	Blk	28:14:3:24	5:23:10:50	6
512	2T1BP000		S	Blk	28:14:15:6	5:23:22:33	6
513	2T1BP001		SD		28:14:15:54	5:23:23:20	6
514	2T1BP002		S		28:14:27:36	5:23:35:2	6
515	2T1BP003		SD		28:14:28:24	5:23:35:50	6
516	2T1BP004		S		28:14:40:5	5:23:47:31	6
517	2T1BP005		SD		28:14:40:53	5:23:48:20	6
518	2T1BP006	****	S		28:14:52:35	6:0:0:1	6
519	2T1BP007	****	SD		28:14:53:23	6:0:0:50	6
520	2T1BP008		S		28:15:5:6	6:0:12:32	6
521	2T1BP009		SD		28:15:5:54	6:0:13:20	6
522	2T1BP010		S		28:15:17:36	6:0:25:2	6
523	2T1BP011		SD		28:15:18:24	6:0:25:50	6
524	2T1BP012		S		28:15:30:6	6:0:37:32	6
525	2T1BP013		SD		28:15:30:54	6:0:38:20	6
526	2T1BP014		S		28:15:42:37	6:0:50:3	6
527	2T1BP015		SD	Drk	28:15:43:25	6:0:50:51	6
528	2T1BP016		S		28:15:55:7	6:1:2:33	6
529	2T1BP017		SD		28:15:55:55	6:1:3:21	6
530	2T1BP018		S		28:16:7:38	6:1:15:4	6
531	2T1BP019		SD		28:16:8:25	6:1:15:51	6
532	2T1BP020		S		28:16:30:5	6:1:37:31	6
533	2T1BP021		SD		28:16:30:53	6:1:38:19	6
534	2T1BP022		S		28:16:52:35	6:2:0:1	6
535	2T1BP023		SD		28:16:53:23	6:2:0:49	6
536	2T1BP024		S		28:17:15:6	6:2:22:32	6
537	2T1BP025		SD		28:17:15:53	6:2:23:19	6
538	2T1BP026		S		28:17:37:35	6:2:45:1	6
539	2T1BP027		SD		28:17:38:23	6:2:45:49	6
540	2T1BP028		S		28:18:0:5	6:3:7:31	6
541	2T1BP029		SD		28:18:0:53	6:3:8:19	6
542	2T1BP030		S		28:18:22:35	6:3:30:1	6
543	2T1BP031		SD		28:18:23:22	6:3:30:48	6
544	2T1BP032		S		28:18:45:4	6:3:52:30	6
545	2T1BP033		SD		28:18:45:51	6:3:53:17	6
546	2T1BP034		S		28:19:7:32	6:4:14:58	6
547	2T1BP035		SD		28:19:8:20	6:4:15:46	6
548	2T1BP036		S		28:19:30:3	6:4:37:29	6
549	2T1BP037		SD		28:19:30:51	6:4:38:17	6
550	2T1BP038		S		28:19:52:33	6:4:59:59	6
551	2T1BP039		SD		28:19:53:21	6:5:0:47	6

**** - DATA LOSS; GMT and MET may not be exact

Holo Number	Hologram Code		Hologram Type	Quality	GMT	MET	TGS Mode
552	2T1CP040		S	Blk	29:0:55:0	6:10:2:26	7
553	2T1CP041		S		29:1:6:42	6:10:14:8	7
554	2T1CP042		S		29:1:18:24	6:10:25:50	8
555	2T1CP043		S		29:1:30:6	6:10:37:32	8
556	2T1CP044		S		29:1:48:45	6:10:56:11	10
557	2T1CP045		S		29:2:0:27	6:11:7:53	10
558	2T1CP046		S		29:2:12:7	6:11:19:33	10
559	2T1CP047		S		29:2:23:48	6:11:31:14	11
560	2T1CP048		S		29:2:35:30	6:11:42:56	11
561	2T1CP049		S		29:2:47:12	6:11:54:38	11
562	2T1CP050		S	Drk	29:2:58:54	6:12:6:20	11
563	2T1CP051	****	S		29:3:10:36	6:12:18:2	11
564	2T1CP052		S		29:3:22:19	6:12:29:45	11
565	2T1CP053		S		29:3:34:1	6:12:41:27	11
566	2T1CP054		S		29:3:45:43	6:12:53:9	11
567	2T1CP055		S		29:3:57:25	6:13:4:51	11
568	2T1CP056		S		29:4:9:7	6:13:16:33	11
569	2T1CP057		S		29:4:20:49	6:13:28:15	11
570	2T1CP058		S		29:4:32:31	6:13:39:57	11
571	2T1CP059		S		29:4:44:14	6:13:51:40	11
572	2T1CP060		S		29:4:55:56	6:14:3:22	11
573	2T1CP061		S		29:5:7:38	6:14:15:5	11
574	2T1CP062		S	Drk	29:5:21:19	6:14:28:45	11
575	2T1CP063		SD	Lgt	29:5:22:7	6:14:29:33	11
576	2T1CP064		DD	Drk	29:5:22:55	6:14:30:21	11
577	2T1CP065		S	Lgt	29:5:32:21	6:14:39:47	11
578	2T1CP066		SD		29:5:33:9	6:14:40:35	11
579	2T1CP067		DD		29:5:33:57	6:14:11:23	11
580	2T1CP068		S		29:5:43:23	6:14:50:49	11
581	2T1CP069		SD		29:5:44:11	6:14:51:37	11
582	2T1CP070		DD		29:5:44:59	6:14:52:25	11
583	2T1CP071		S		29:5:54:26	6:15:1:52	11
584	2T1CP072		SD		29:5:55:14	6:15:2:40	11
585	2T1CP073		DD		29:5:56:2	6:15:3:28	11
586	2T1CP074		S	Lgt	29:6:5:28	6:15:12:54	11
587	2T1CP075		SD		29:6:6:15	6:15:13:41	11
588	2T1CP076		DD		29:6:7:3	6:15:14:29	11
589	2T1CP077		S		29:6:16:29	6:15:23:55	11
590	2T1CP078		SD		29:6:17:17	6:15:24:43	11
591	2T1CP079		DD		29:6:18:5	6:15:25:31	11
592	2T1CP080		S		29:6:27:32	6:15:34:58	11
593	2T1CP081		SD		29:6:28:20	6:15:35:46	11
594	2T1CP082		DD		29:6:29:8	6:15:36:34	11
595	2T1CP083		S		29:6:38:35	6:15:46:1	11
596	2T1CP084		SD		29:6:39:23	6:15:46:49	11
597	2T1CP085		DD		29:6:40:11	6:15:47:37	11

**** - DATA LOSS; GMT and MET may not be exact

Holo Number	Hologram Code	Hologram Type	Quality	GMT	MET	TGS Mode
598	2T1CP086	S		29:6:54:39	6:15:2:5	11
599	2T1CP087	SD		29:6:55:27	6:16:2:53	11
600	2T1CP088	DD	Cut50%	29:6:56:15	6:16:3:41	11
601	2T1CP089	S	Cut50%	29:7:5:41	6:16:13:7	11
602	2T1CP090	SD	Cut50%	29:7:6:29	6:16:13:55	11
603	2T1CP091	DD		29:7:7:17	6:16:14:43	11
604	2T1CP092	S		29:7:16:44	6:16:24:10	11
605	2T1CP093	SD		29:7:17:31	6:16:24:57	11
606	2T1CP094	DD		29:7:18:19	6:16:25:45	12
607	2T1CP095	S		29:7:27:45	6:16:35:11	12
608	2T1CP096	SD		29:7:28:33	6:16:35:59	12
609	2T1CP097	DD		29:7:29:21	6:16:36:47	12
610	2T1CP098	S	Loan	29:7:38:47	6:16:46:13	12
611	2T1CP099	SD		29:7:39:35	6:16:47:1	12
612	2T1CP100	DD		29:7:40:23	6:16:47:49	12
613	2T1CP101	S		29:7:49:49	6:16:57:15	12
614	2T1CP102	SD		29:7:50:37	6:16:58:3	12
615	2T1CP103	DD		29:7:51:25	6:16:58:51	12
616	2T1CP104	S		29:8:0:52	6:17:8:18	12
617	2T1CP105	SD		29:8:1:40	6:17:9:6	12
618	2T1CP106	DD		29:8:2:27	6:17:9:53	12
619	2T1CP107	S		29:8:11:54	6:17:19:20	12
620	2T1CP108	SD		29:8:12:41	6:17:20:7	12
621	2T1CP109	DD		29:8:13:29	6:17:20:55	12
622	2T1CP110	S		29:8:22:55	6:17:30:21	12
623	2T1CP111	SD		29:8:23:43	6:17:31:9	12
624	2T1CP112	DD		29:8:24:31	6:17:31:57	12
625	2T1CP113	S		29:8:33:58	6:17:41:24	12
626	2T1CP114	SD		29:8:34:46	6:17:42:12	12
627	2T1CP115	DD		29:8:35:34	6:17:43:0	12
628	2T1CP116	S		29:8:45:0	6:17:52:26	12
629	2T1CP117	SD		29:8:45:48	6:17:53:14	12
630	2T1CP118	DD		29:8:46:36	6:17:54:2	12
631	2T1CP119	S		29:8:56:2	6:18:3:28	12
632	2T1CP120	SD		29:8:56:50	6:18:4:16	12
633	2T1CP121	DD		29:8:57:38	6:18:5:4	12
634	2T1CP122	S		29:9:7:5	6:18:14:31	12
635	2T1CP123	SD		29:9:7:53	6:18:15:19	12
636	2T1CP124	DD		29:9:8:41	6:18:16:7	12
637	2T1CP125	S		29:9:18:7	6:18:25:33	12
638	2T1CP126	SD		29:9:18:55	6:18:26:21	12
639	2T1CP127	DD		29:9:19:43	6:18:27:9	12
640	2T1CP128	S		29:9:29:10	6:18:36:36	12
641	2T1CP129	SD		29:9:29:58	6:18:37:24	12
642	2T1CP130	DD		29:9:30:46	6:18:38:12	12
643	2T1CP131	S		29:9:40:11	6:18:47:37	12

**** - DATA LOSS; GMT and MET may not be exact

Holo Number	Hologram Code	Hologram Type	Quality	GMT	MET	TGS Mode
644	2T1CP132	SD		29:9:40:59	6:18:48:25	12
645	2T1CP133	DD		29:9:41:47	6:18:49:13	12
646	2T1CP134	S		29:10:8:25	6:19:15:51	12
647	2T1CP135	SD		29:10:9:13	6:19:16:39	12
648	2T1CP136	DD		29:10:10:1	6:19:17:27	12
649	2T1CP137	S		29:10:19:27	6:19:26:53	12
650	2T1CP138	SD		29:10:20:15	6:19:27:41	12
651	2T1CP139	DD		29:10:21:3	6:19:28:29	12
652	2T1CP140	S		29:10:30:30	6:19:37:56	12
653	2T1CP141	SD		29:10:31:18	6:19:38:44	12
654	2T1CP142	DD		29:10:32:6	6:19:39:32	12
655	2T1CP143	S		29:10:41:33	6:19:48:59	12
656	2T1CP144	SD		29:10:42:20	6:19:49:46	12
657	2T1CP145	DD		29:10:43:8	6:19:50:34	12
658	2T1CP146	S		29:10:52:34	6:20:0:0	12
659	2T1CP147	SD		29:10:53:22	6:20:0:48	12
660	2T1CP148	DD		29:10:54:10	6:20:1:36	12
661	2T1CP149	S		29:11:3:36	6:20:11:2	12
662	2T1CP150	SD		29:11:4:24	6:20:11:50	12
663	2T1CP151	DD		29:11:5:12	6:20:12:38	12
664	2T1CP152	S		29:11:14:39	6:20:22:5	12
665	2T1CP153	SD		29:11:15:27	6:20:22:53	12
666	2T1CP154	DD		29:11:16:15	6:20:23:41	12
667	2T1CP155	S		29:11:25:41	6:20:33:7	12
668	2T1CP156	SD		29:11:26:29	6:20:33:55	12
669	2T1CP157	DD		29:11:27:17	6:20:34:43	12
670	2T1CP158	S		29:11:36:43	6:20:44:9	12
671	2T1CP159	SD		29:11:37:31	6:20:44:57	12
672	2T1CP160	DD		29:11:38:19	6:20:45:45	12
673	2T1CP161	S		29:11:47:45	6:20:55:11	12
674	2T1CP162	SD		29:11:48:33	6:20:55:59	12
675	2T1CP163	DD		29:11:49:21	6:20:56:47	12
676	2T1CP164	S		29:11:58:47	6:21:6:13	12
677	2T1CP165	SD		29:11:59:35	6:21:7:1	12
678	2T1CP166	DD		29:12:0:23	6:21:7:49	12
679	2T1CP167	S		29:12:9:50	6:21:17:16	12
680	2T1CP168	SD		29:12:10:38	6:21:18:4	12
681	2T1CP169	DD		29:12:11:26	6:21:18:52	12
682	2T1CP170	S		29:12:20:52	6:21:28:18	12
683	2T1CP171	SD		29:12:21:40	6:21:29:6	12
684	2T1CP172	DD		29:12:22:28	6:21:29:54	12
685	2T1CP173	S		29:12:31:55	6:21:39:21	12
686	2T1CP174	SD		29:12:32:43	6:21:40:9	12
687	2T1CP175	DD		29:12:33:31	6:21:40:57	12
688	2T1CP176	S		29:12:42:58	6:21:50:24	12
689	2T1CP177	SD		29:12:43:46	6:21:51:12	12

**** - DATA LOSS; GMT and MET may not be exact

Holo Number	Hologram Code	Hologram Type	Quality	GMT	MET	TGS Mode
690	2T1CP178	DD		29:12:44:33	6:21:51:59	12
691	2T1CP179	S		29:12:54:0	6:22:1:26	12
692	2T1CP180	SD	Blk	29:12:54:48	6:22:2:14	12
693	2T1CP181	S	Exp20%	29:13:11:54	6:22:19:20	12
694	2T1CP182	SD		29:13:12:41	6:22:20:7	12
695	2T1CP183	DD		29:13:13:29	6:22:20:55	12
696	2T1CP184	S		29:13:22:55	6:22:30:21	12
697	2T1CP185	SD		29:13:23:43	6:22:31:9	12
698	2T1CP186	DD		29:13:24:31	6:22:31:57	12
699	2T1CP187	S		29:13:33:58	6:22:41:24	12
700	2T1CP188	SD		29:13:34:46	6:22:42:12	12
701	2T1CP189	DD		29:13:35:34	6:22:43:0	12
702	2T1CP190	S		29:13:44:59	6:22:52:25	12
703	2T1CP191	SD		29:13:45:47	6:22:53:13	12
704	2T1CP192	DD		29:13:46:35	6:22:54:1	12
705	2T1CP193	S		29:13:56:1	6:23:3:27	12
706	2T1CP194	SD		29:13:56:49	6:23:4:15	12
707	2T1CP195	DD		29:13:57:37	6:23:5:3	12
708	2T1CP196	S		29:14:7:4	6:23:14:30	12
709	2T1CP197	SD		29:14:7:52	6:23:15:19	12
710	2T1CP198	DD		29:14:8:40	6:23:16:6	12
711	2T1CP199	S		29:14:18:6	6:23:25:32	12
712	2T1CP200	SD		29:14:18:53	6:23:26:20	12
713	2T1CP201	DD		29:14:19:41	6:23:27:7	12
714	2T1CP202	S		29:14:29:6	6:23:36:32	12
715	2T1CP203	SD		29:14:29:54	6:23:37:21	12
716	2T1CP204	DD		29:14:30:42	6:23:38:8	12
717	2T1CP205	S		29:14:40:8	6:23:47:35	12
718	2T1CP206	S	Blk	29:17:17:35	7:2:25:1	12
719	2T1CP207	SD		29:17:18:23	7:2:25:50	12
720	2T1CP208	DD		29:17:19:11	7:2:26:37	12
721	2T1CP209	S		29:17:28:37	7:2:36:3	12
722	2T1CP210	SD		29:17:29:25	7:2:36:52	12
723	2T1CP211	DD		29:17:30:13	7:2:37:39	12
724	2T1CP212	S		29:17:39:39	7:2:47:5	12
725	2T1CP213	SD		29:17:40:27	7:2:47:53	12
726	2T1CP214	DD		29:17:41:15	7:2:48:41	12
727	2T1CP215	S		29:17:50:41	7:2:58:7	12
728	2T1CP216	SD		29:17:51:29	7:2:58:55	12
729	2T1CP217	DD		29:17:52:17	7:2:59:43	12
730	2T1CP218	S		29:18:1:44	7:3:9:10	12
731	2T1CP219	SD		29:18:2:32	7:3:9:58	12
732	2T1CP220	DD		29:18:3:20	7:3:10:46	12
733	2T1CP221	S		29:18:12:46	7:3:20:12	12
734	2T1CP222	SD		29:18:13:34	7:3:21:0	12
735	2T1CP223	DD		29:18:14:21	7:3:21:47	12

**** - DATA LOSS; GMT and MET may not be exact

Holo Number	Hologram Code		Hologram Type	Quality	GMT	MET	TGS Mode
736	2T1CP224		S		29:18:23:47	7:3:31:13	12
737	2T1CP225		SD		29:18:24:35	7:3:32:1	12
738	2T1CP226		DD		29:18:25:23	7:3:32:49	12
739	2T1CP227		S	Exp25%	29:18:34:49	7:3:42:15	12
740	2T1CP228		SD		29:18:35:37	7:3:43:3	12
741	2T1CP229		DD		29:18:36:25	7:3:43:51	12
742	2T1CP230	****	S		29:18:45:51	7:3:53:17	12
743	2T1CP231	****	SD		29:18:46:39	7:3:54:5	12
744	2T1CP232	****	DD		29:18:47:27	7:3:54:53	12
745	2T1CP233	****	S		29:18:56:53	7:4:4:19	12
746	2T1CP234	****	SD		29:18:57:41	7:4:5:7	12
747	2T1CP235	****	DD		29:18:58:29	7:4:5:55	12
748	2T1CP236	****	S		29:19:7:55	7:4:15:21	12
749	2T1CP237	****	SD		29:19:8:43	7:4:16:9	12
750	2T1CP238	****	DD		29:19:9:31	7:4:16:57	12
751	2T1CP239	****	S		29:19:18:57	7:4:26:23	12
752	2T1CP240	****	SD		29:19:19:45	7:4:27:11	12
753	2T1CP241	****	DD		29:19:20:33	7:4:27:59	12
754	2T1CP242	****	S		29:19:29:59	7:4:37:25	12
755	2T1CP243	****	SD		29:19:30:47	7:4:38:13	12
756	2T1CP244	****	DD		29:19:31:35	7:4:39:1	12
757	2T1CP245	****	S		29:19:41:1	7:4:48:27	12
758	2T1CP246	****	SD		29:19:41:49	7:4:49:15	12
759	2T1CP247	****	DD		29:19:42:37	7:4:50:3	12
760	2T1CP248	****	S		29:19:52:3	7:4:59:29	12

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[RUN1C.RUN1C_240S.248]/20

APPENDIX B:

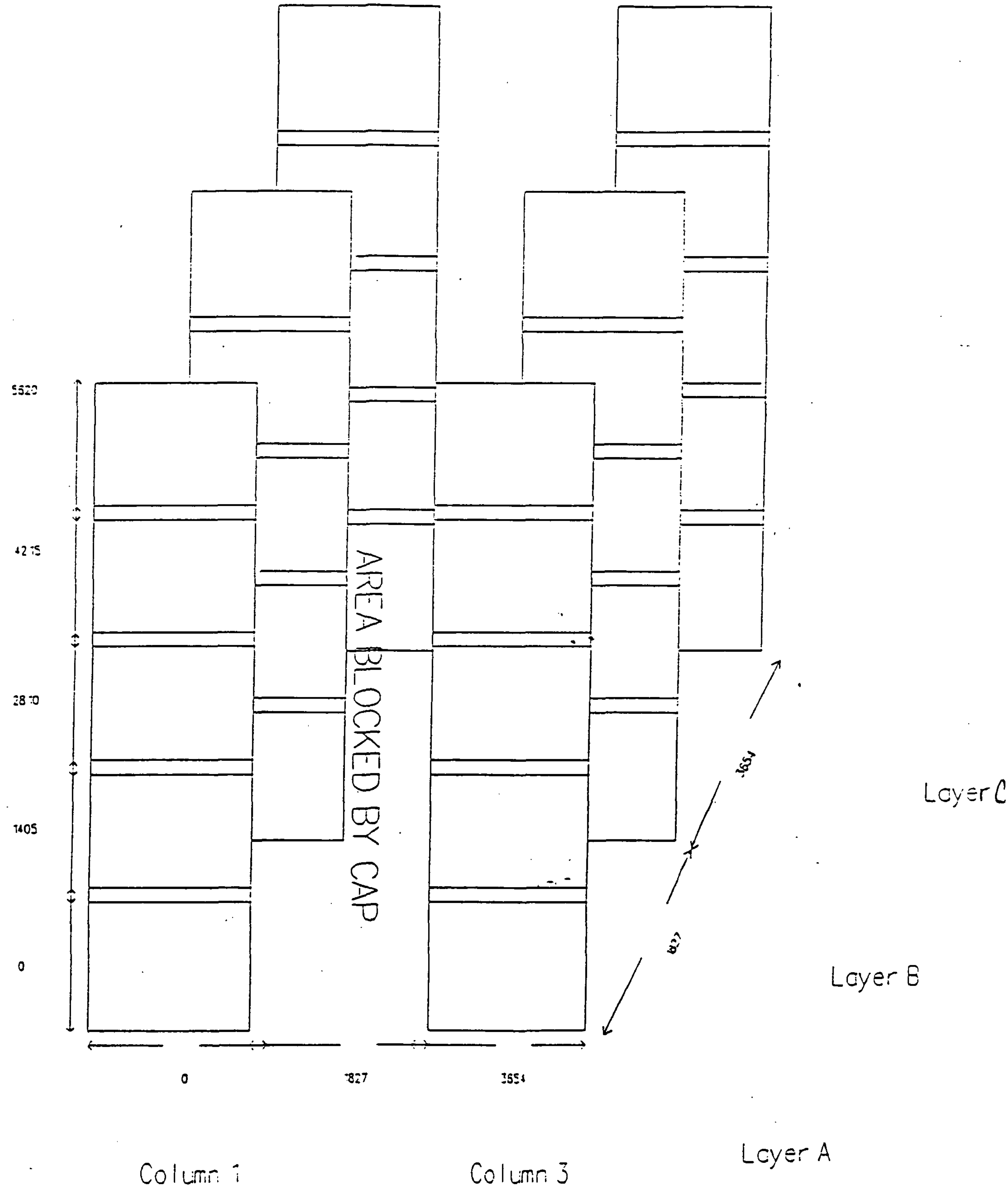
IMAGES, MATRICES, AND ACQUISITION PROCEDURES

IMAGE ACQUISITION PROCEDURE FOR THE TGS 1A EXPERIMENT

Using the Unidex, move the camera to the reference point on the image.
While in the appropriate directory, enter the CHIP program.
If the camera is not in the correct plane of focus, move to it now.

CM TRANSLATION
HOLOCODE
ANGLE 1(PLANE A,B,OR C)
AUTOGRAB
INC X -100
GO
INC X 0
INC Y -1405
GO (4 TIMES)
ANGLE 3(PLANE A,B,OR C)
INC X 8400
INC Y 0
GO
INC X 0
INC Y 1405
GO (3 TIMES)
AUTOGRAB OFF
RESET X,Y
AUTO UNIDEX OFF
UNIDEX ONLINE OFF
EXIT
EXIT

FIGURE 1 - RUN 1A IMAGE MATRIX



All units in steps (1 step = 5 microns)

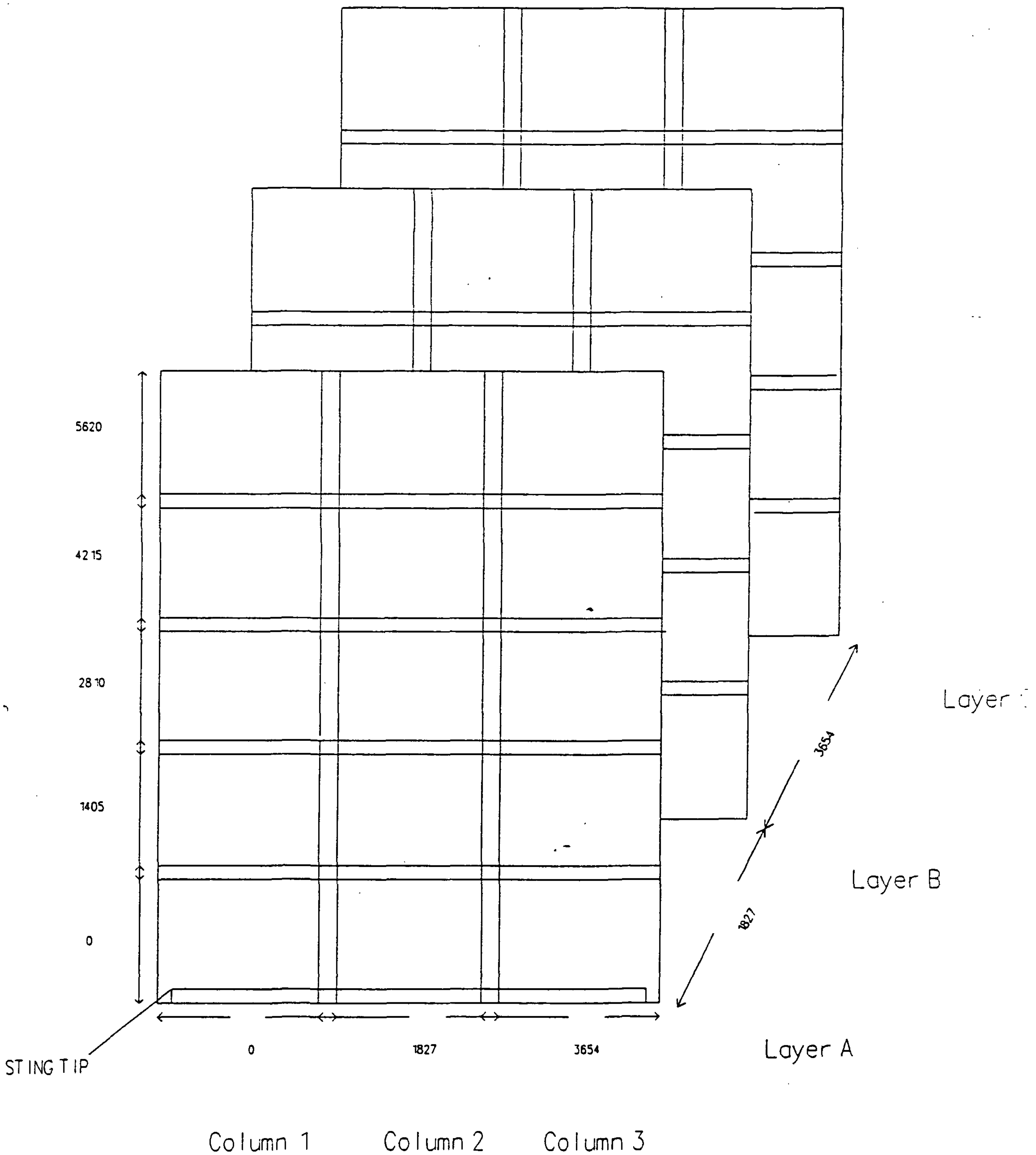
Frame size = 2030W x 1562H

IMAGE ACQUISITION PROCEDURE FOR THE TGS 1C EXPERIMENT

Using the Unidex, move the camera to the reference point on the image.
While in the appropriate directory, enter the CHIP program.
If the camera is not in the correct plane of focus, move to it now.

CM TRANSLATION
HOLOCODE
ANGLE 1(PLANE A,B,OR C)
AUTOGRAB
INC X 500
GO
INC X 0
INC Y -1405
GO (4 TIMES)
ANGLE 2(PLANE A,B,OR C)
INC X 1827
INC Y 0
GO
INC X 0
INC Y 1405
GO (4 TIMES)
ANGLE 3(PLANE A,B,OR C)
INC X 1827
INC Y 0
GO
INC X 0
INC Y -1405
GO (4 TIMES)
AUTOGRAB OFF
RESET X,Y
AUTO UNIDEX OFF
UNIDEX ONLINE OFF
EXIT
EXIT

FIGURE 2 - RUN 1C IMAGE MATRIX



All units in steps (1 step = 5 microns)

Frame size = 2030W x 1562H

APPENDIX C:
CAMERA ALIGNMENT PROCEDURE

CAMERA ALIGNMENT PROCEDURE

1. Insert neutral density filters so that the camera can be placed in the direct path of the reference beam without washing out the image.

2. Turn the glass platen so that it is perpendicular to the reference beam and the face of the camera.

3. Make sure that there is not too much light. To control the amount of light recorded by the camera, adjust the camera's shutter or gain as necessary.

4. Translate the camera to find the horizontal vacuum groove in the platen.

5. Make sure this groove is parallel with the table surface.

6. Rotate the camera in its mount so that the groove appears to be at the same height on both sides of the screen.

7. Start at one end of the groove and translate horizontally to make sure it remains at a constant height. If not, then make necessary adjustments to level the mount base.

8. Translate the camera to the vertical groove.

9. Start at one end of the groove and translate vertically to check that there is no horizontal movement of the groove. If so, then make the necessary adjustments to level the mount base.

10. Translate back to the horizontal groove and change the focus of the camera. If there is vertical movement, then adjust the screws on the base as needed and repeat steps 7 through 10 as necessary.

11. Mount a hologram on the platen, remove the filters, and rotate the platen back to the normal 22.5 degrees from the reference beam. Make sure the shutter and gain are set correctly.

12. Translate the camera in the focus direction. Repeat step 10, checking for horizontal instead of vertical movement.

13. If the image has an inherent tilt, adjust the rotation of the film platen.

APPENDIX D:
IMAGE TRANSFER AND STORAGE PROCEDURE

IMAGE TRANSFER AND STORAGE PROCEDURE

The following steps will allow the user to store image files on the optical disk housed in SSL (Space Science Lab). This procedure assumes that the images have already been acquired using the CHIP program and are stored on the Bernoulli disks.

- Type "CD DECNET" to change the current to the network directory

- Type "STARTNET" to start the network

- Type the username and password at the SSLMOR VAX prompt
  USERNAME: ______
  PASSWORD: ______
  (The system forces a password change periodically.)

- Create the needed directories on the SSL VAX scratchpad:
  CREATE /DIR SSL$SCRATCH:[SCRATCH.2T1CP099]

- Type "set host sam" to logon onto the SAM VAX

- Type the username and passowrd at the SAM VAX prompt:
  USERNAME: ______
  PASSWORD: ______
  (The SOAR software menu should appear.)

- Use the OMOUNT (option #3) menu selection to mount the optical disk:
  - accept default pseudo device name (QSA0:)
  - accept default physical device name (SAM$DUA0:)
  - specify the disk label (iml1_mic_pab)
  - specify the magfile disk and filename:
    DISK3:[SOARDATA]MAG_IML1_PAB.$SOAR$
  - answer "Y" to the /SYSTEM prompt
  - answer "Y" to the /WRITE prompt
  - answer "N" to the /NOSECURE prompt

+ Press <CTRL+F9> to get back to the DOS prompt

+ Type NFT to enter the Network File Transfer program

+ Transfer the image files using the following syntax
  COPY/IMAGE E:\2T1AP099*.*
  SSLMOR"HGS"::SSL$SCRATCH:[SCRATCH.2T1AP099]*.*

(The previous step copies the images from the Bernoulli disk (d: or e:) to the directory specified on the SSLMOR disk.)

+ Type "exit" to return to the DOS prompt

+ Type "exit" to return to the SAM VAX prompt

+ Use the OCOPY (option #4) menu selection to copy files to the optical disk:
  - specify input file
    SSL$SCRATCH:[SCRATCH.2t1AP099]*.*
  - specify output file
    QSA0:[RUN1A.RUN1A_090S.099]*.*
  - answer "Y" to the /LOG prompt
  - answer "Y" to the /VERIFY prompt
  - answer "Y" to the /ERROR prompt

- Repeat the steps marked above with " + " symbol until all the image files have been copied to the optical disk

NOTE: At this point in the procedure all the files should have been successfully copied onto the optical disk. The following steps prepare the optical disk for removal and cleans up the SSLMOR VAX scratchpad disk.

- Use the ODISMOUNT (option #5) menu selection to dismount the optical disk.
  - accept default pseudo device name (QSA0:)
  - accept default physical device name (SAM$DUA0:)
  - enter disk label (iml1_mic_pab)

- Use the LOGOFF FROM THE NODE (option #0) menu selection to escape from the SOAR software. This will put you back to the SSLMOR VAX prompt.

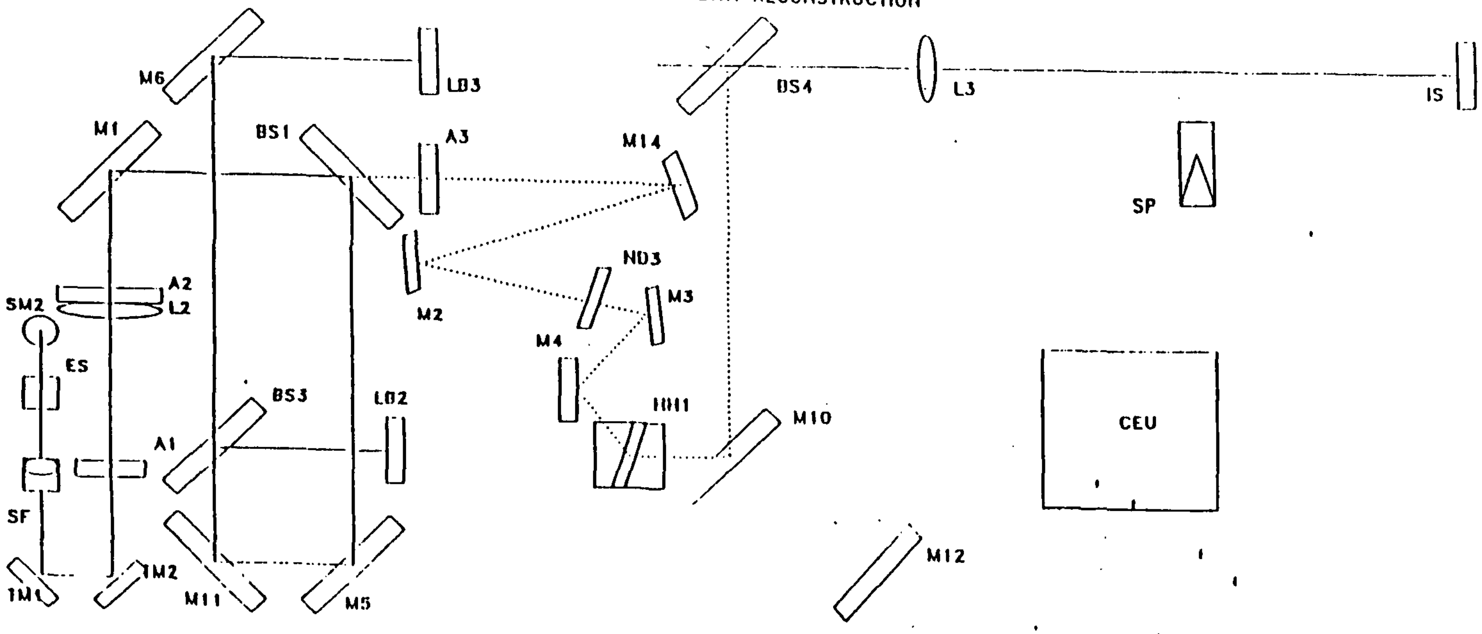
- Delete all the files in each subdirectory created on the scratchpad disk:
  DEL SSL$SCRATCH:[SCRATCH.2T1AP099]*.*;*

- Change the protection for each subdirectory created on the scratchpad disk:
  SET PROTECTION SSL$SCRATCH:[SCRATCH]2T1AP099.DIR
  /PROTECTION=OWNER:D

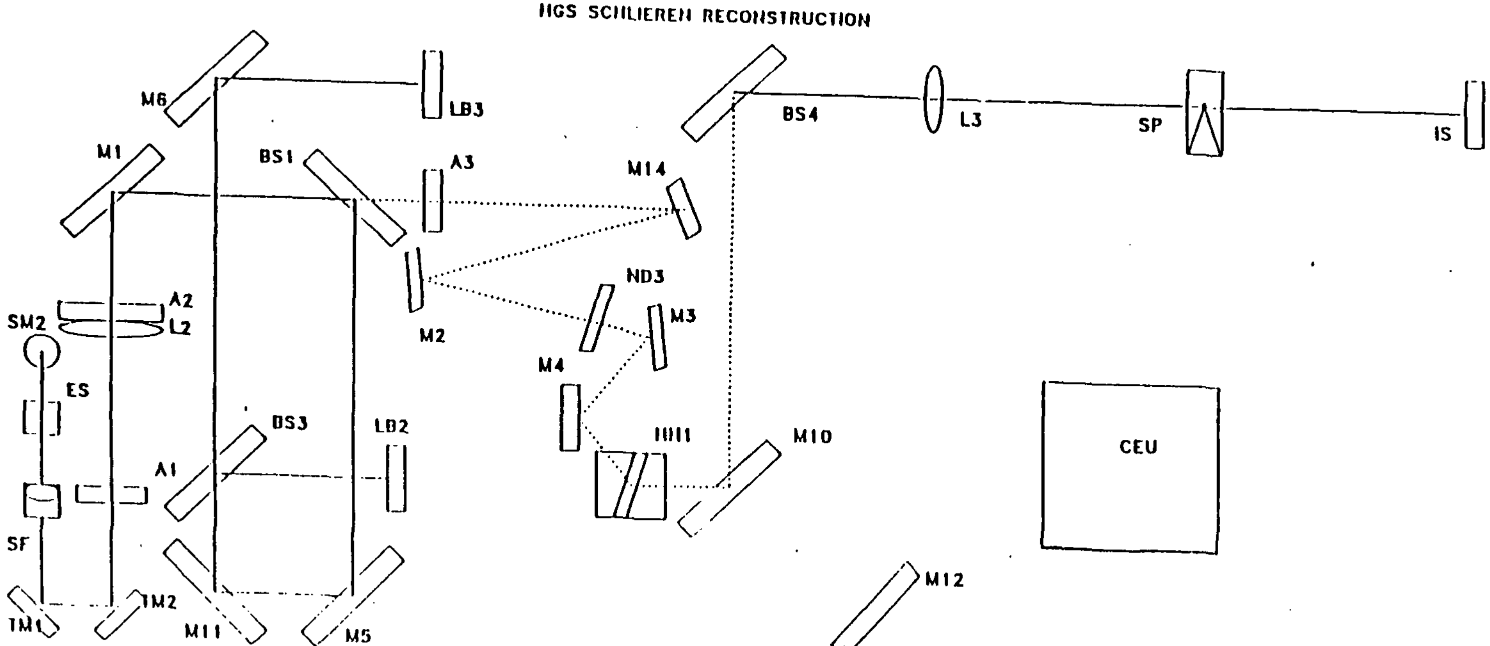
- Delete each subdirectory that was created:
  DEL SSL$SCRATCH:[SCRATCH]2T1AP*.DIR;*

APPENDIX E:
OPTICAL BENCH LAYOUTS

HGS INTERFEROMETRY RECONSTRUCTION



HGS SCHLIEREN RECONSTRUCTION



HGS SHADOWGRAPH RECONSTRUCTION

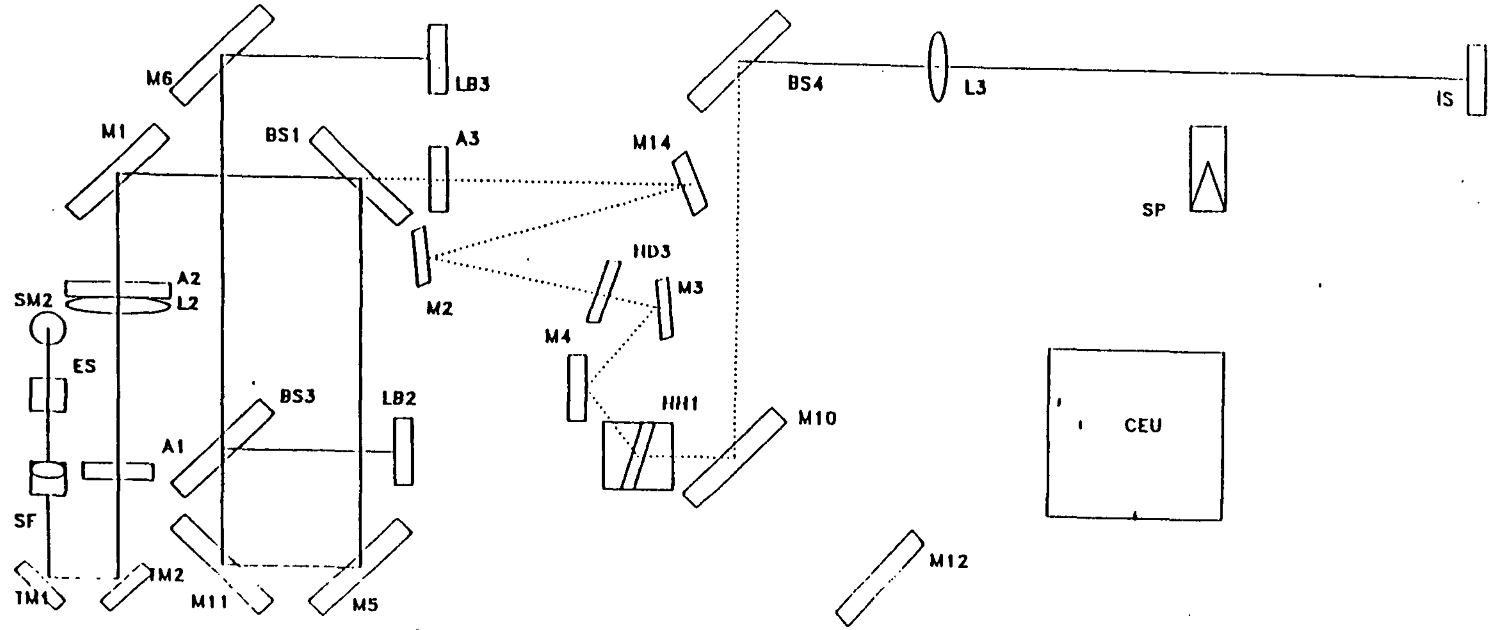


TABLE OF ABBREVIATIONS

A - Aperture	M - Mirror
BS - Beamsplitter	ND - Neutral Density Filter
CEU - Cell Electronics Unit	SF - Spatial Filter
HH - Hologram Holder	SM - Steering Mirror
IS - Interferometric Screen	SP - Schlieren Probe
L - Lens	TM - Turning Mirror
LB - Light Blocker	

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15. Supplementary Notes

16. Abstract

Processing and data reduction of holographic images from Spacelab presents some interesting challenges in determining the effects of microgravity on crystal growth processes. Evaluation of several processing techniques, including the Computerized Holographic Image Processing System and the Software Development Package (SDP-151) will provide fundamental information for holographic and schlieren analysis of the space flight data.

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